POST-TRAINING PERFORMANCE CRITERION DEVELOPMENT AND APPLICATION

The Development of Unidimensional Scales for the Dimensions Derived from a Multidimensional Scale Analysis of the Job of the Naval Aviation Electronics Technician

Prepared For
Personnel and Training Branch
OFFICE OF NAVAL RESEARCH
Under Contract Nonr-2279(00)

Applied Psychological Services
Wayne, Pennsylvania

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ABSTRACT

Four dimensions had previously been extracted in a multidimensional scaling analysis of the Naval aviation electronics technician's job at the entry level. The purpose of the present study was to construct unidimensional scales on each of these dimensions, utilizing methods developed earlier by Applied Psychological Services. For each dimension, a set of tasks was found which formed a scale as defined by both the Thurstone method of equal appearing intervals and the Guttman technique.

ACKNOWLEDGMENTS

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The contribution of LT C. F. Olsen of the Staff of the Commander Naval Air Force, U. S. Atlantic Fleet, in coordinating the arrangements for the collection of the required Fleet data was of inestimable value.

Several other members of the Applied Psychological Services staff provided able support to the project. Mr. Philip Federman and Mr. Richard Lanterman performed the statistical analyses. Miss Gail Gensemer and Mrs. Estelle Siegel carried out the varied secretarial duties that are involved in a project of this kind.

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CHAPTER 1

INTRODUCTION

The feasibility of applying multidimensional scaling techniques for job analysis and job descriptive purposes has been examined in three previous Applied Psychological Services' studies (Schultz and Siegel, 1962; Siegel and Schultz, 1963; Schultz and Siegel, 1963b). These were the most recent efforts in a progressive, systematic attack on problems in the development of job proficiency criteria for graduates of Naval training programs in several technical specialties. Earlier studies (Schultz and Siegel, 1961; Siegel and Schultz, 1962) had produced methods for constructing job task performance criterion instruments which meet the Thurstone and/or Guttman scalability requirements. The research described in this report related these two areas of development in order to obtain a new type of criterion measurement instrument for use in the Navy.

Multidimensional scaling analysis has as its principal purpose the determination of the number of basic dimensions (factors) underlying a set of perceptions. The characteristics of and names for the extracted dimensions should be apparent from inspection of the scale values of the stimuli on each axis. In the first application of multidimensional scaling to job tasks, Schultz and Siegel (1962) studied the job of the striker and petty officer, third class,

Naval aviation electronics technician (AT). Four underlying factors were found to account for this job as seen by immediate supervisors in the rating. The dimensions were called "electro-comprehension," "equipment operation and inspection (routine)," "electro-repair (simple)," and "electro-safety." The report described the dimensions as "reasonable and meaningful" and went on to point out that:

> Furthermore, these four dimensions appear to be amenable to unidimensional scaling, i.e., they possess characteristics which would seem to make it possible to develop unidimensional scales to measure each of them. Since the dimensions extracted in the present study represent the underlying structure of the job performed by striker and third class AT's, as perceived by their supervisors, the next logical step in measuring that job performance would appear to be the construction of unidimensional scales on each of the dimensions. . . . . If unidimensional, scaled instruments are constructed, it will then be possible to evaluate the job performance of individuals on each of the orthogonal dimensions seen by AT supervisors as composing the job. (Schultz and Siegel, 1962, p. 36).

As mentioned above, methods for measuring job performance on a Thurstone or a Guttman type of scale resulted from previous work carried out at Applied Psychological Services. Those studies (Schultz and Siegel, 1961; Siegel and Schultz, 1962) involved the twin steps of: (1) demonstrating that job task skills are scalable according to the definitions of scalability of each of the two approaches, and (2) developing check lists of job tasks in a form that could be applied easily and economically in the evaluation of the job performance

of individuals. Use of the check lists, which met the Thurstone and the Guttman scalability requirements, called for simple, two-category responses to clearly and directly stated questions.

Because of the manner in which the directions and questions were formulated in those first studies of Thurstone and Guttman scales of job performance, scores on the scaled check lists reflected the general developmental stage or level of the Naval technician being evaluated. There appeared to be no reason, however, why the same methods, slightly adapted, could not be applied to each one of the dimensions extracted in a multidimensional scaling analysis of a job.

Purposes of the Present Study

The purposes of the present study were to: (1) investigate the feasibility of developing unidimensional scales along each of the dimensions extracted in a multidimensional scaling analysis of job performance, and (2) produce practical scales, meeting the Thurstone and Guttman scalability requirements, which could be used for evaluating individual technicians along the four dimensions previously found to underlie the job of the striker and the petty officer, third class, Naval aviation electronics technician.

CHAPTER II

DEVELOPMENT OF THURSTONE EQUAL APPEARING INTERVAL SCALES FOR JOB PERFORMANCE DIMENSIONS

The principal output of a multidimensional scaling analysis is a matrix of the scale values (projections) of each stimulus on each dimension of a set of stimuli. The present study was to build upon the results of the analysis by Schultz and Siegel (1962) of the jobs of the striker and the petty officer, third class, Naval aviation electronics technician. Therefore, the starting point was a matrix of the loadings of 18 tasks on each of four dimensions. (The matrix can be found in Table 8, page 23, of the Schultz and Siegel report.)

Several different approaches were possible to the construction of unidimensional scales along the four dimensions. One, analogous to the development of "pure factor" tests, would have called for writing four new series of job tasks, each series to include only tasks which were thought to represent varying amounts of one dimensional variable but not to involve the other dimensions. This approach, although possible, appeared to represent a more formidable undertaking than the one adopted. As an alternative approach, the original 18 tasks could be used, even though they all tended to be loaded on more than one dimension. In this approach, the subjects of the study who would be making scale judgments would be asked to view a complex stimulus, i.e., a job task, from the standpoint of its relationship to each dimension separately. If this method proved

to be feasible, it would have the further advantage of indicating whether the stimulus scale positions on each dimension as determined by the direct perceptions of judges are closely related to the scale values, i.e., the projections, of the stimuli on that dimension, as it emerged from the multidimensional scaling analysis. It was decided to take the latter approach because: (1) it did not involve the burden of writing new task descriptions in "pure" dimensional form, and (2) it seemed more likely to produce a fruitful result.

The Technical Task Evaluation List

Review of the 18 job tasks found to constitute the job of the striker and petty officer, third class, aviation electronics technician suggested that the relationship of some of the tasks to certain of the dimensions would be so abstruse or so very obvious (e.g., "using proper safety precautions for self" in relation to "electro-safety") as simply to confuse the subjects and serve only to interfere with the proper placement of the remaining tasks along the particular continuum. Therefore, for three of the dimensions, several tasks were eliminated from further consideration. The tasks included for analysis on each dimension are indicated by X's in the appropriate columns of Table 1.

The Technical Task Evaluation List was then constructed for the purpose of obtaining the judgments required in developing Thurstone equal-appearing intervals scales. Each of the sections pertained to one of the four dimensions being treated. The over-all directions, printed on the cover page, were:

> There are four sections in this form, each containing a number of tasks which are customarily done by AT strikers. You will be asked to evaluate the tasks listed in a section from a certain point of view, but this point of view will differ from one section to another. Therefore, be sure you understand how you are to evaluate the tasks each time. Read the directions for each section very carefully, even though there is some repetition in them.

In each section the respondent was given a continuum with eleven equally spaced points indicated (except for the third section which involved only nine points). The dimension under consideration was briefly defined and the respondent was asked to judge each of the listed tasks only from the standpoint of that dimension. The low, middle, and high areas on the continuum were described. The judge was asked to indicate the placement of each task on the continuum by means of gummed, prenumbered stickers, which were distributed symmetrically with generally larger frequencies in the middle categories. The stickers were used in order to force the judges to distribute their responses widely and more or less normally. In each section the tasks were listed in an order determined from random numbers tables; furthermore, the order was varied from one section to another.

The "directions page" for the first section, pertaining to electro-comprehension, is presented in Table 2.

TABLE 1

Tasks Used for Scale Development on Each Dimension

Task	Electro-comprehension*	Operation and Inspection	Electro-repair	Electro-safety
Performing variety of "housekeeping" duties such as cleaning shop, repairing tools, etc.	x			
Performing routine line operations	x	x	x	x
Standing watch	x	x	x	x
Performing minor inspections of avionic equipments	x	x	x	x
Performing intermediate inspections of avionic equipments	x	x	x	x
Performing preflight inspections of avionic equipments	x	x	x	x
Performing postflight inspections of avionic equipments	x	x	x	x
Operating avionic equipments	x	x	x	x
Using safety precautions on equipments	x			
Using proper safety precautions for self	x			
Removing malfunctioning avionic parts/equipment from planes	x	x		x
Replacing repaired avionic parts/equipment in planes	x	x		x
Performing preventive maintenance on avionic equipments	x	x	x	x
Following block diagrams for avionic equipments	x			x
Using schematics for standard circuits in avionic equipments	x			
Making out reports (failure, etc.)	x	x		x
Using inspection and operation manuals	x			
Operating standard test equipment for determining malfunctions in avionic equipments	x	x	x	x

*An "x" in a column means the task was included for unidimensional scaling of that dimension.

TABLE 2

Directions Page for Section 1 of Technical Task Evaluation List

In Section 1 there are 18 tasks which call for various amounts of knowledge and understanding of the principles of avionic circuitry. First, you should read over the tasks to see what they are. Then, using the scale below as a guide, you are to judge each task ONLY from the standpoint of the knowledge and understanding of the principles of avionic circuitry that it requires. Follow the procedure described in the steps given below. If you wish, before you use the stickers you may write your responses in with a pencil and then go back and attach the stickers.

1 2 3 4 5 6 7 8 9 10 11

REQUIRES LITTLE KNOWLEDGE AND UNDERSTANDING OF PRINCIPLES OF AVIONIC CIRCUITRY

REQUIRES MODERATE KNOWLEDGE AND UNDERSTANDING OF PRINCIPLES OF AVIONIC CIRCUITRY

REQUIRES GREAT KNOWLEDGE AND UNDERSTANDING OF PRINCIPLES OF AVIONIC CIRCUITRY

1. First place the sticker with the 11 on it next to the task that requires the greatest knowledge and understanding of the principles of avionic circuitry.

2. Then pick the task that requires the next greatest knowledge and understanding of avionic circuitry and put the sticker with the 10 on it next to that task.

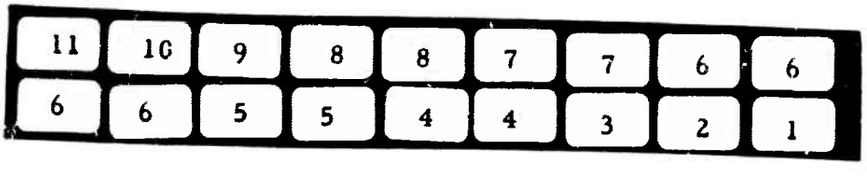
3. Now find the task that falls in category "nine" and place the sticker with the 9 on it next to that task.

4. Next find the task that requires the least knowledge and understanding of the principles of avionic circuitry. Put the sticker with the 1 on it next to this task.

5. Which task requires the next smallest knowledge and understanding of avionic circuitry? Put the sticker with the 2 on it next to this task.

6. Put the sticker with the 3 on it next to the task that falls in category "three."

7. Now place the remaining tasks in their proper categories by applying the remaining stickers (4, 5, 6, 7, 8).



In these directions the respondent was asked to judge each of the tasks listed from the standpoint of the extent to which it requires knowledge and understanding of the principles of avionic circuitry. The directions for the tasks relating to the second and third extracted dimensions (operation and inspection, and electro-repair) preceded the second and third sections of the form. These directions asked the respondent for estimates of the level of ability required for each of the listed tasks in terms of level of ability in equipment turn-on, warm-up, run, and shut-down procedures and in terms of level of ability in the removal of, making required corrections in, and the replacement of avionic equipment. The fourth and last sections of the form, relative to electro-safety, asked for an estimate of the extent to which safety precautions are employed in performing each of the listed tasks.

The complete Technical Task Evaluation List is shown in Appendix A to this report.

Sample

The Technical Task Evaluation List was administered to 40 chief petty officers and petty officers, first class, in the Naval aviation electronics technician (AT) rating. * The squadrons to which these judges were assigned and their

*At the time of responding, two of the subjects were in the anti-submarine warfare technician (AX) rating, a new rating for electronics technicians specializing in that area of work. Each of these men had previously been an AT for 5 years.

locations are presented in Table 3. Their average age was 31.3 years and they had 12.4 years of military experience, on the average. For approximately eight years, they had been AT's and had been assigned during this time to an average of 3.2 squadrons.

Administration

Two groups, one at each of the two Naval Air Stations involved, were assembled for administration of the Technical Task Evaluation List. In order to make certain that the men read the directions to each section and that they understood what they were to do, the administrator kept the group together, i.e., he read the directions for a section to the group, asked for questions, and then had everyone wait until all the men were finished with that section before proceeding to the next section. Completion of the form consumed about one hour. Responding to the first section, containing the most tasks, seemed to take quite a while, but the later sections went more quickly.

From the purely mechanical point of view, the administration of the Technical Task Evaluation List seemed to proceed well. Only one person became confused writing in the numbers before affixing the numbered stickers, a procedure suggested in the directions. The few questions that the respondents asked involved the meaning of the task descriptions. The group gave the appearance of understanding and being able to accomplish its assignments; informal conversations with some of the subjects after the sessions supported this view.

Table 3

Number of Supervisors, by Location and Squadron, Completing Technical Task Evaluation List

Location	Squadron	Number
Norfolk	FAETULANT	2
	HS 3	2
	HS 7	2
	HU 2	1
	VAW 12	2
	VP 56	2
	VRC 40	2
	VRF 31	2
	VS 24	1
	VS 26	2
	VS 27	2
	VS 36	2
	VU 6	2
Oceana	VA 42	2
	VA 81	2
	VA 83	3
	VA 85	1
	VF 74	3
	VF 103	1
	VU 2	2
	VU 4	2
		40

Results

In order for a scale to achieve the requirements of a Thurstone scale, equal-appearing between-scale value distances are sought. To establish a scale by the Thurstone method of equal-appearing intervals, the median and semi-interquartile range of the judges' decisions are taken as the scale and deviation (Q) values of the stimuli. Therefore, for each task in each section of the Technical Task Evaluation List, these two statistics were computed. Plots of the resulting data for the four sections are presented in Figures 1, 2, 3, and 4.

Examination of the four plots reveals, first of all, that in each case the full range of the scale was utilized. The scale values are distributed well over the scales and the highest and lowest values generally come closer to the extremes of the scales than had been true in earlier work on scaling tasks (Schultz and Siegel, 1961; Siegel and Schultz, 1962). The Q values are, for the most part, fairly small, indicating relative agreement among the judges as to the task placement on the scales and suggesting the probability of good discrimination among the tasks. There is some slight tendency for the Q values to be higher for the tasks with higher S values in Sections 2 and 4 of the Technical Task Evaluation List.

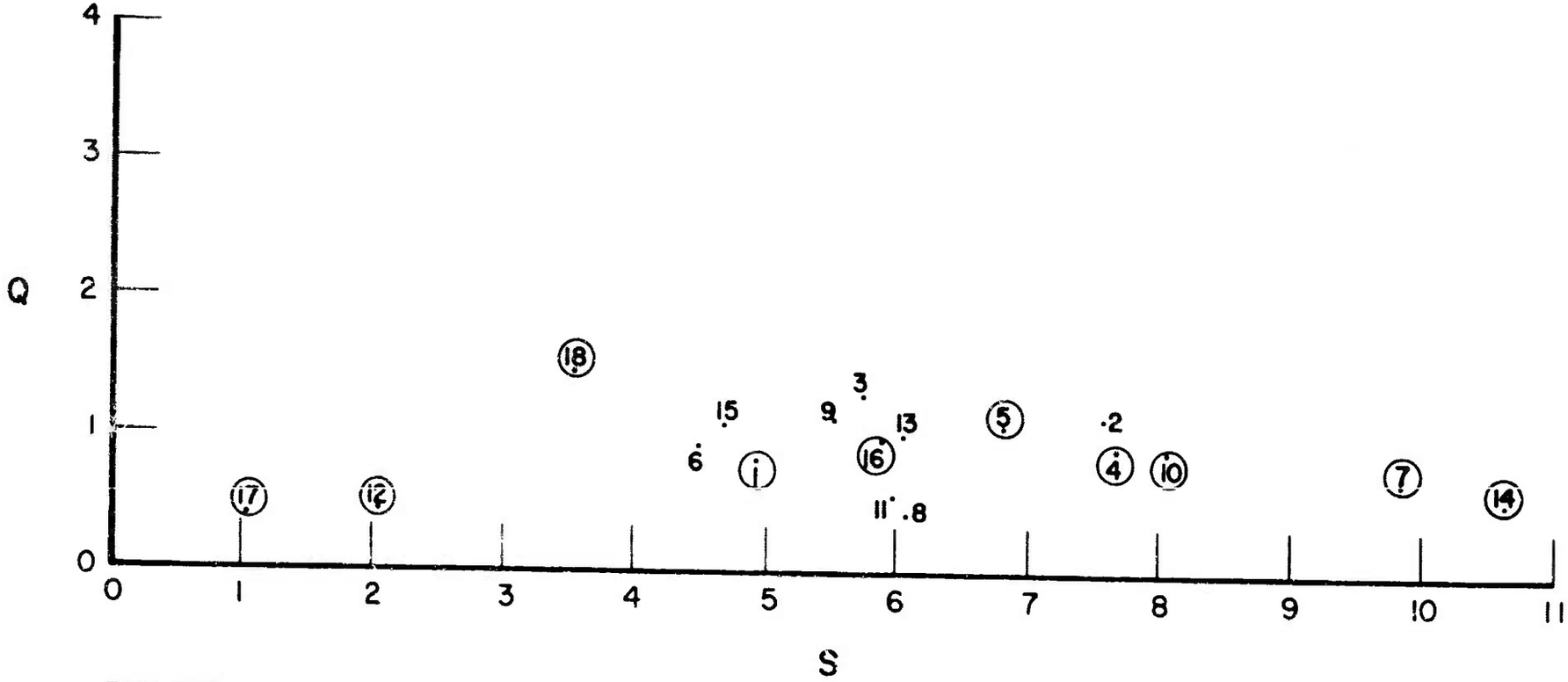


FIGURE 1. SCALE VALUE (S) AND SEMI INTERQUARTILE RANGE (Q) FOR EACH TASK IN SECTION 1 OF TECHNICAL TASK EVALUATION LIST

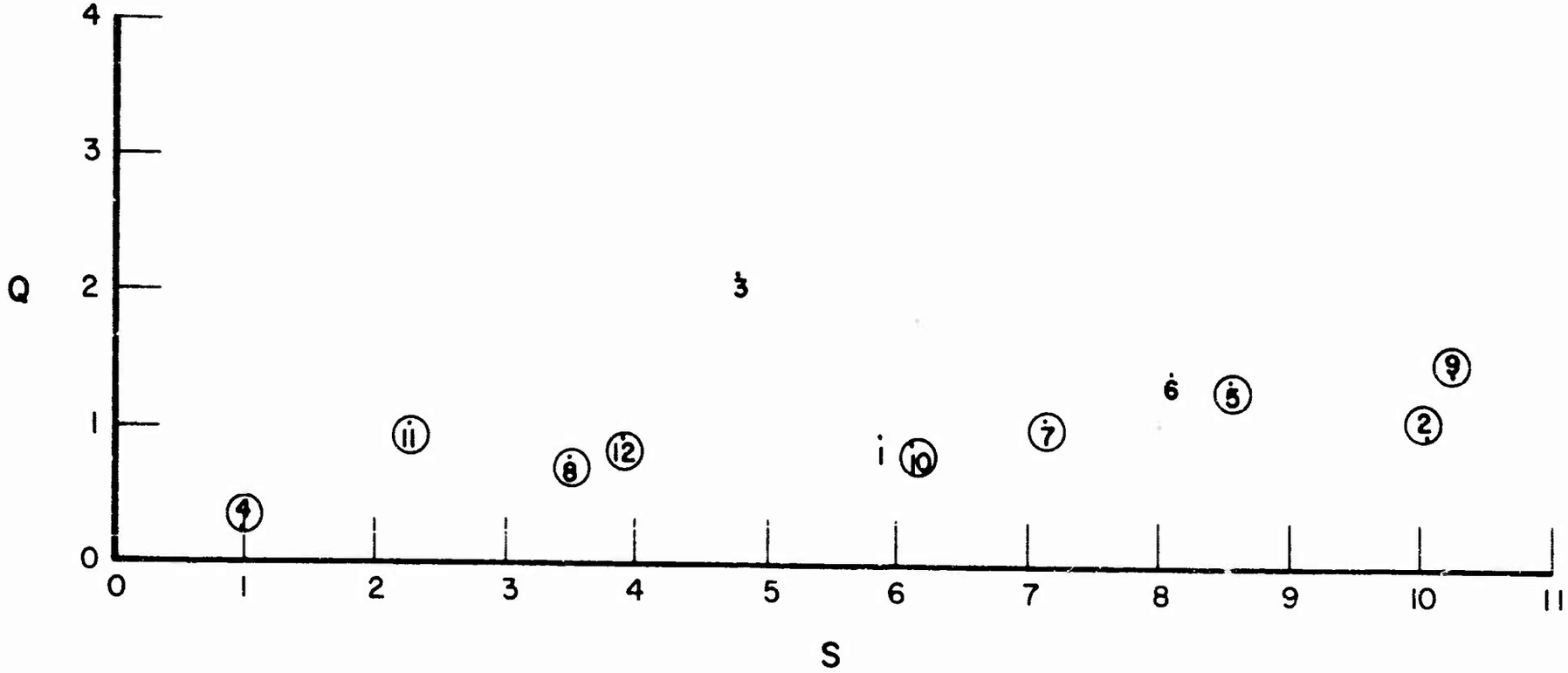


FIGURE 2. SCALE VALUE (S) AND SEMI INTERQUARTILE RANGE (Q) FOR EACH TASK IN SECTION 2 OF TECHNICAL TASK EVALUATION LIST

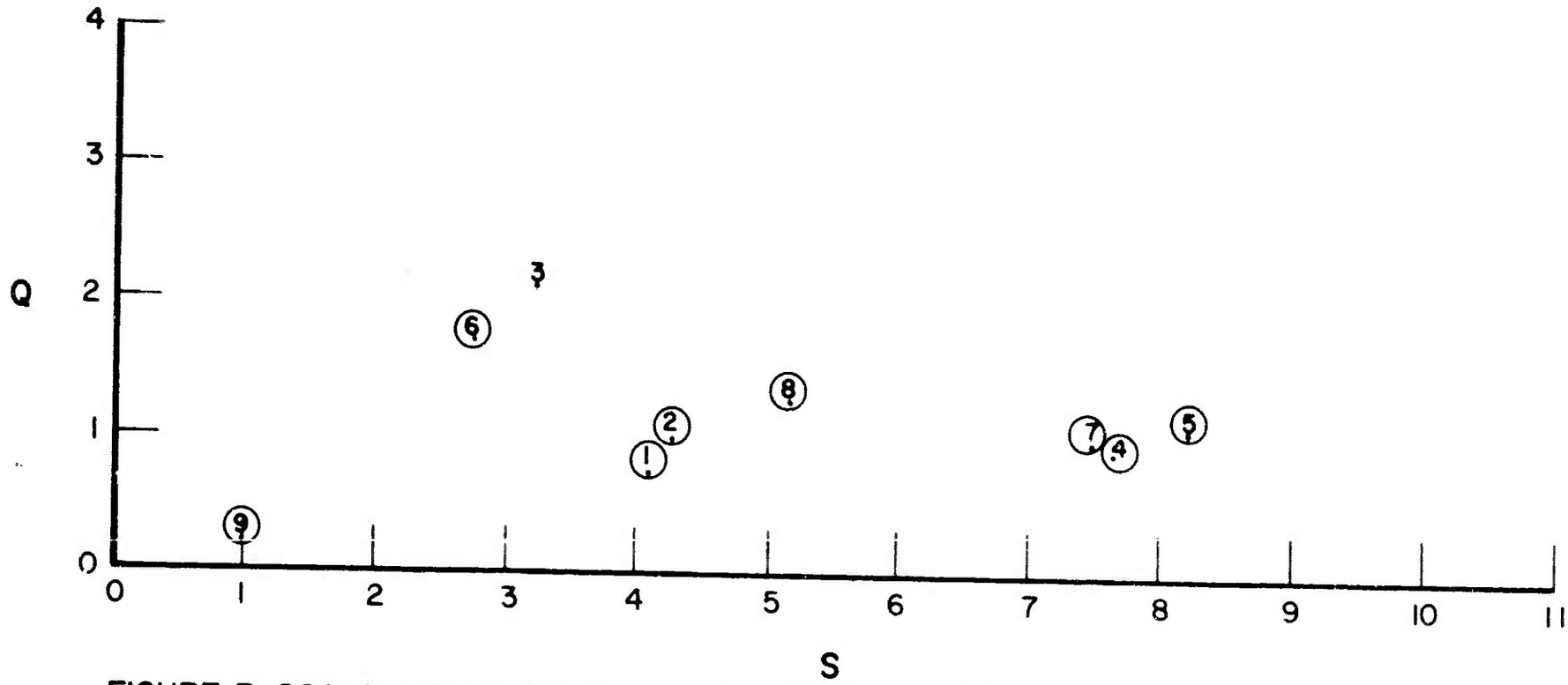


FIGURE 3. SCALE VALUE (S) AND SEMI INTERQUARTILE RANGE (Q) FOR EACH TASK IN SECTION 3 OF TECHNICAL TASK EVALUATION LIST

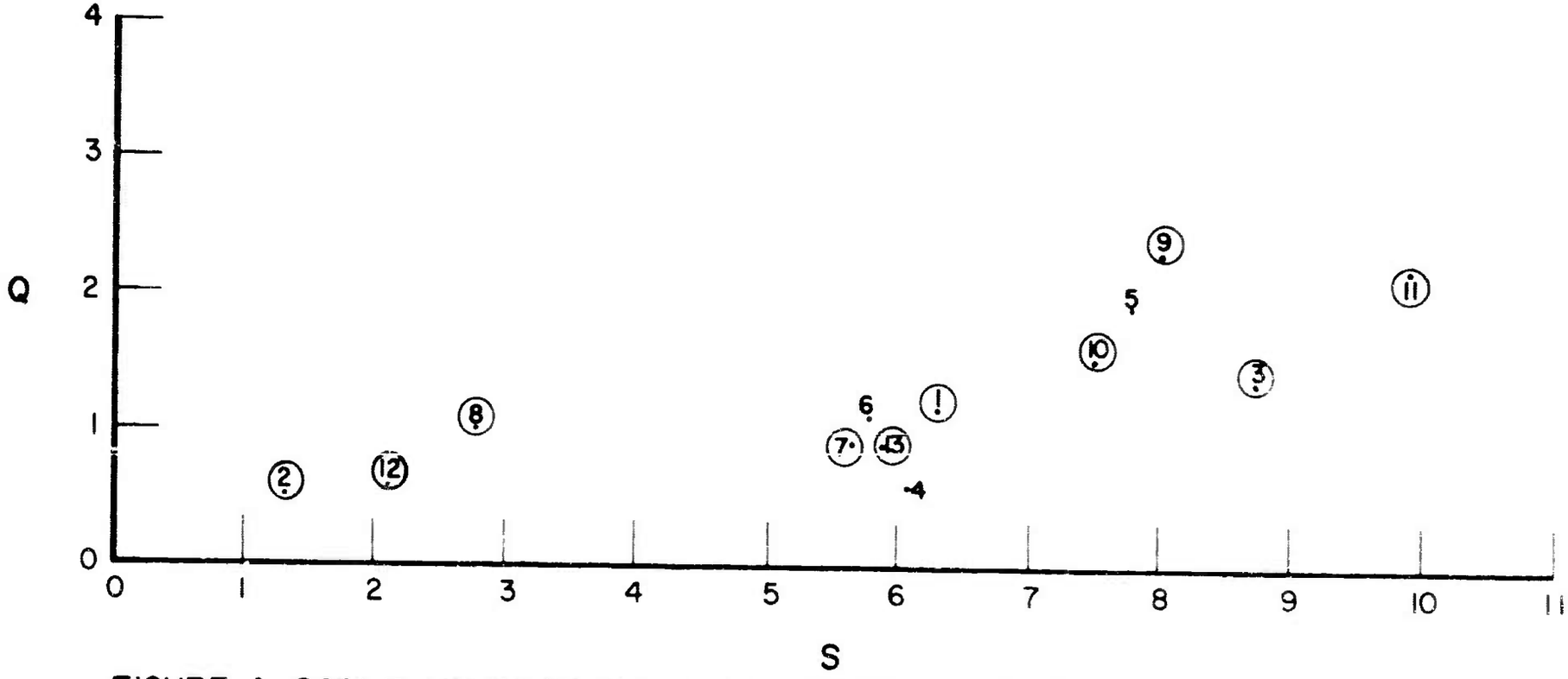


FIGURE 4. SCALE VALUE (S) AND SEMI INTERQUARTILE RANGE (Q) FOR EACH TASK IN SECTION 4 OF TECHNICAL TASK EVALUATION LIST

Correlation of Obtained Scale Values with Task Loadings on Each Dimension

For each task included in a section of the Technical Task Evaluation List two numbers representing the position of that task on the dimension involved had been obtained. On the one hand, the loading derived from the multidimensional scaling analysis (Schultz and Siegel, 1962, p. 28) was the projection of the task on the dimension. On the other hand, the Thurstone scale value produced in this study grew out of an appraisal of the task as it related to the defined dimension. The former constituted the results of an indirect approach, i.e., an analysis of over-all judgments of the similarity among all the original tasks. The latter was a direct placement of each task along a defined scale. The two resultant numbers should be highly correlated provided: (1) the dimensions produced in the multidimensional scaling analysis are meaningful and interpretable, (2) the descriptions of the dimensions in the Technical Task Evaluation List are accurate and complete reflections of the dimensional characteristics, and (3) each of the approaches gives stable indices of the task scale placements.

For each section of the Technical Task Evaluation List, i.e., for each dimension, the Pearson product-moment correlation coefficient was computed between the two sets of scale values described above. The results were as follows:

Dimension	r
Electro-comprehension (18 tasks)	.38
Operation and inspection (12 tasks)	.79
Electro-repair (9 tasks)	.67
Electro-safety (13 tasks)	.50

In each case, the rank of at least one or two tasks was noticeably different in the two sets of data being correlated. In the "electro-repair" section, the task of "operating standard test equipment for determining malfunctions in avionic equipments" was given the highest Thurstone scale value but was seventh in the group of nine tasks from the standpoint of dimensional loadings. In the "electro-safety" section, there were three instances of large variations: "standing-watch" was first in dimensional loading and eleventh in Thurstone scale value; "performing preventive maintenance on avionic equipments" was tenth in dimensional loading and second in Thurstone scale value; and "performing intermediate inspections of avionic equipments" was eleventh in dimensional loading and fifth in Thurstone scale value. These relatively large differences undoubtedly played a major role in reducing the correlation coefficients for the sections involved as compared with the values which might have been otherwise obtained, since the N's on which the computations were based were not large.

Over-all, the correlation coefficients given above lend considerable support to a contention supporting the validity of multidimensional scaling analytic

techniques when they are applied to job task data, i.e., the scaling methods produce meaningful results which can be verified from other points of view. Since similar scale values were obtained for most of the tasks studied in the two approaches, the exceptions are probably most satisfactorily explained in terms of the construction of the Technical Task Evaluation List, rather than in terms of the inadequacies of multidimensional scaling methodology or the instability of the results. A plausible explanation of the discrepancies, for example, is that all of the details of the underlying dimensions extracted in the multidimensional scaling analysis were not clearly defined and/or some of the more refined aspects of the dimensions were not fully communicated to the men who made the Thurstone scale judgments. The high level of the correlation coefficients, however, indicates that, for the most part: (1) the dimensions are meaningful, (2) the nature of the dimensions was accurately represented in the Technical Task Evaluation List, and (3) the scale values produced by both analytical methods are reliable.

Item Selection for Thurstone Type Scales

The construction of a Thurstone type of scale requires a series of items which, on the one hand, have a wide scattering of S values so that the entire continuum is represented and, on the other hand, have small Q values so that they overlap minimally in perceived scale placement. Within each section of the Technical Task Evaluation List, a selection of items was made to meet these

two requirements as closely as possible. The items constituting the Thurstone scale for each dimension, i.e., each Evaluation List section, are presented in Tables 4-7, along with their S and Q values. It is thus demonstrated that it is possible to build unidimensional Thurstone scales along each of the dimensions extracted in a multidimensional scaling analysis when the stimuli consist of job tasks.

Table 4

S (Scale) and Q (Semi-Interquartile Range) Values of Items Selected for Thurstone Scale on Dimension 1, Electro-comprehension

Task	S	Q
Standing watch	1.11	.31
Performing variety of "housekeeping" duties such as cleaning shop, repairing tools, etc.	2.04	.39
Using proper safety precautions for self	3.62	1.30
Replacing repaired avionic parts/equipment in planes	4.88	.81
Performing minor inspections of avionic equipments	5.81	.86
Using inspection and operation manuals	6.88	1.13
Performing intermediate inspections of avionic equipments	7.68	.82
Performing preventive maintenance on avionic equipments	8.03	.88
Operating standard test equipment for determining malfunctions in avionic equipments	9.81	.72
Using schematics for standard circuits in avionic equipments	10.67	.54

Table 5

S (Scale) and Q (Semi-Interquartile Range) Values of Items Selected for Thurstone Scale on Dimension 2, Equipment Operation and Inspection

Task	S	Q
Standing watch	1.00	.25
Making out reports (failure, etc.)	2.33	1.01
Removing malfunctioning avionic parts/ equipment from planes	3.50	.81
Replacing repaired avionic parts/equipment in planes	3.96	.90
Performing postflight inspections of avionic equipments	6.18	.92
Performing preflight inspections of avionic equipments	7.20	1.12
Performing preventive maintenance on avionic equipments	8.62	1.45
Operating avionic equipments	10.06	1.00
Operating standard test equipment for determining malfunctions in avionic equipments	10.33	1.49

Table 6

S (Scale) and Q (Semi-Interquartile Range) Values of Items Selected for Thurstone Scale on Dimension 3, Electro-repair

Task	S	Q
Standing watch	1.00	.25
Performing routine line operations	2.83	1.85
Performing postflight inspections of avionic equipments	4.03	.76
Performing preflight inspections of avionic equipments	4.32	1.00
Performing minor inspections of avionic equipments	5.21	1.31
Performing intermediate inspections of avionic equipments	7.50	1.00
Performing preventive maintenance on avionic equipments	7.73	.94
Operating standard test equipment for determining malfunctions in avionic equipments	8.21	1.08

Table 7

S (Scale) and Q (Semi-Interquartile Range) Values of Items Selected for Thurstone Scale on Dimension 4, Electro-safety

Task	S	Q
Making out reports (failure, etc.)	1.33	.51
Following block diagrams for avionic equipments	2.17	.56
Standing watch	2.83	1.00
Performing minor inspections of avionic equipments	5.68	.88
Replacing repaired avionic parts/equipment in planes	5.79	.88
Performing preflight inspections of avionic equipments	6.39	1.25
Performing intermediate inspections of avionic equipments	7.50	1.54
Performing routine line operations	8.00	2.30
Performing preventive maintenance on avionic equipments	8.77	1.37
Operating standard test equipment for determining malfunctions in avionic equipments	9.93	2.29

CHAPTER III

DEVELOPMENT OF GUTTMAN SCALES FOR JOB PERFORMANCE DIMENSIONS

The application to the job task performance area of the Guttman method for scaling items has been investigated and demonstrated in Applied Psychological Services' studies previously mentioned (Schultz and Siegel, 1961; Siegel and Schultz, 1962). The technique involves testing the item response data to determine whether a hierarchy exists among the respondents such that each person's over-all position can be inferred from the highest item in the set to which he answers affirmatively. If such an order can be established, the items are said to scale and it can be assumed that an individual giving an affirmative response to one item will have a high probability of giving an affirmative response to all the items ranking "lower" in the set. Since the earlier studies concluded that it is possible to scale job tasks by the Guttman method, the question under investigation in the current study was whether Guttman scales could be constructed along the dimensions which grew out of a multidimensional scaling analysis.

The Proficiency Check List

A Guttman scale analysis requires data in terms of the responses of individuals to the scale items. In the present case, this meant that a form was

needed which would permit the evaluation of individuals rather than of tasks. The Proficiency Check List was designed to accomplish this purpose.

In certain respects, the Proficiency Check List was similar to the Technical Task Evaluation List described in the previous Chapter. Each of the four sections was related to one of the dimensions produced in the multidimensional scaling analysis of the job of the striker and petty officer, third class, Naval aviation electronics technician (Schultz and Siegel, 1962). Also, only those items indicated in Table 1 of this report were included, as in the Technical Task Evaluation List, to avoid unnecessary confusion. In a more general sense, the Proficiency Check List took the same approach as the Technical Task Evaluation List in that task descriptions as they appeared in the multidimensional scaling analysis work were used, rather than "pure dimensional" task descriptions. In this approach, the man being evaluated was to be judged on his competency on only those aspects of a task that were related to a single dimension at a time.

The directions on the cover page of the Proficiency Check List asked the man completing the form to:

> Think of an AT striker whom you have supervised and whose capabilities you know well. You are to evaluate him in four different ways. There are four sections in this form, each containing a number of tasks which are customarily done by AT strikers. You will be asked to evaluate the man you are considering with respect to the various tasks from a certain point of view, but this point of view will differ

from one section to another. Therefore, be sure you understand how you are to do the evaluations each time. Read the directions for each section very carefully, even though there is some repetition in them.

Write down a response for every task. If the man you are evaluating has not done a task or if you have not seen him do it, try to make your best estimate of the evaluation.

The instructions for each section first gave a brief explanation of the dimension under consideration (without naming it) and pointed out that the tasks included in the list for that section involved the dimensional characteristics to a varying degree. In evaluating the man, the respondent was to view each task only from the standpoint of that dimension. Specifically, the directions for Section 1 were:

In Section 1 there are 18 tasks which call for various amounts of knowledge and understanding of the principles of avionic circuitry. You should think of the man you are evaluating. Does he have the knowledge and understanding of the principles of avionic circuitry required by the first task? If he does, make a check in the box under "Yes"; if he does not, make a check in the box under "No." Then look at the second task and indicate your evaluation of the man by a check mark in the appropriate box. Continue on down the page making a check mark in one box next to each task. Remember, you are to evaluate the man ONLY with respect to whether or not he has the knowledge and understanding of the principles of avionic circuitry required by each task. Even if he has not done the task or if you have not seen him do it, make your best estimate of his capability with regard to it. Be sure to make a check mark next to each task in the list.

Similarly, Sections 2, 3, and 4 respectively asked the respondent to judge whether the man he evaluated is:

a. capable of performing proficiently the equipment turn-on, warm-up, run, and shut-down procedures involved in each task

b. capable of performing proficiently the removal of, making required corrections in, and the replacement of avionic equipment involved in each task

c. capable of performing the safety precautions involved in each task listed.

Within the sections, the tasks were presented in a random order which was different for each section and all of which differed from the orders used in the Technical Task Evaluation List. Thus, the respondent was not expected to "read into" the list any underlying scale as a result of a systematic order of presentation.

The complete Proficiency Check List is given in Appendix B of this report.

Sample

A group of 28 strikers and petty officers, third class, in the Naval aviation electronics technician rating were evaluated on the Proficiency Check List. The squadrons to which these men were assigned and their locations are presented in Table 8.

TABLE 8

Number of Technicians, by Location and Squadron, Evaluated on Proficiency Check List

Location	Squadron	Number
Patuxent River	AEWTULANT	8
	VP 8	5
	VR 1	3
Argentia (Newfoundland)	VW 11	1
	VW 13	1
Bermuda	VP 49	4
Brunswick	VP 7	1
Moffett Field	VR 8	1
Naples (Italy)	VR 24	4
		28

Administration

The subjects of this experiment were evaluated by 14 chief petty officers and petty officers, first class, in the AT rating who were located at Patuxent River Naval Air Station and who were assigned to one of the following squadrons: AEWTULANT, VP 8, VP 49, and VR 1. The Proficiency Check List was administered to the entire group at one time. None of the other forms described in this report were completed by these men.

The raters were asked to select a man who was one of the poorer workers they had supervised. They reported having known the ratees an average of 13.8 months, with a range of from 3 to 36 months.

The average age of the raters was 30.8 years and they had an average of 13.2 years of military service. In general, they had been AT's for 10.7 years and been assigned to 4.4 squadrons as AT's.

No problems were encountered in the administration of the Proficiency Check List.

Analytic Method

Following the procedure of the earlier scaling studies, the method of Guttman analysis described by Green (1956) was employed. In this method an index of consistency, I, is used to replace the several requirements for scalability proposed by Guttman. I relates the obtained reproducibility to that

expected by chance. Green suggests that I should be .50 or higher in order to consider the set of items a scale in the Guttman sense, although he points out there is no rationale for setting any rigid cutting point.

As in the previous work, the sets of tasks to be tested for Guttman scalability consisted of the tasks selected for the Thurstone scales. That is, only the tasks selected for inclusion in the Thurstone scale for each dimension (as described in Chapter II of this report) were used in the analysis of that dimension. As a result, the numbers of tasks in Sections 1-4 of the Proficiency Check List for which respondent data were involved in the present analysis were 10, 9, 8, and 10, respectively. In effect, the Thurstone analysis functioned as a first step in the Guttman analysis.

Results

The results of the Guttman scalability analysis for the four dimensions are presented in Table 9. All four I values are well above .50. This suggests that scales which meet Green's criterion of scalability in the Guttman sense have been achieved.

TABLE 9

Results of Guttman Scalability Analysis for the Four Sections of the Proficiency Check List

Section Number and Dimension Name	Rep*	Rep_I**	I***
1. Electro-comprehension (Knowledge and understanding of the principles of avionic circuitry)	.957	.887	.619
2. Equipment operation and inspection (Equipment turn-on, warm-up, run, and shut-down procedures)	.968	.901	.677
3. Electro-repair (Removal of, making the required corrections in, and replacement of avionic equipment)	.969	.880	.742
4. Electro-safety (Safety precautions)	.975	.890	.773

* Reproducibility
** Reproducibility expected by chance
*** Index of consistency

CHAPTER IV

DISCUSSION

The results presented in Chapters II and III tend to indicate that it is possible for judges to view job tasks and technicians from several different viewpoints and to make meaningful ratings of the tasks and people on the various dimensions involved. Apparently judges are able to change their set in response to rather simple and straightforward instructions. Scales were produced which call for merely a "yes" or a "no" response to a small number of items, so that the scales should be convenient and practical to use in the Fleet.

It is quite possible, of course, that unidimensional scales could be developed by some other approach to the construction of the scale items. It might be profitable, for example, to attempt to construct scales of a "pure factor" type and to compare the utility of scales produced through that approach with the scales produced in the current study.

Now that Thurstone and Guttman type scales are available for each of the orthogonal dimensions extracted in a multidimensional scaling analysis, the question may be raised as to how the scales should be weighted if they are to be combined in an over-all evaluation of a man. Solution to this problem is not merely a matter of putting back together what has been taken apart by multidimensional scaling, since there are many bases for deriving weights The matter of weighting job components has been mentioned as a major problem area in a recent survey

of problems and progress in job performance measurement (Schultz and Siegel, 1963a): In the present case, it would seem that some kind of importance values for each of the dimensions might prove useful.

The present scale developmental study was based on the results of a previous Applied Psychological Services' study (Siegel and Schultz, 1962) in which it was found that, at least for the job performance domain, the establishment of a Thurstone scale represents a reasonable and efficient first step in the development of a Guttman scale. The results of the present study lend further support to this previous finding.

Other open questions involve how and whether the scales might be employed for providing information on the technical proficiency of the fleet. Unanswered also is the question of the correlation of proficiency ratings obtained by the current method with ratings obtained through other evaluative techniques, such as work sample performance tests, which possess higher face validity.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

Applied Psychological Services has been making a progressive, systematic attack on a series of related problems in the development of job proficiency criteria for graduates of Naval training programs in several technical specialties. Earlier studies (Siegel and Schultz, 1962) investigated the hypothesis that job performance skills are scalable in the same manner as attitudes and sensory phenomena. The methods developed in those studies for producing job performance scales which meet Thurstone and/or Guttman requirements were tested for applicability across several related job specialties (Schultz and Siegel, 1961). Attention was then turned to the analysis of job performance through the application of multidimensional scaling techniques (Schultz and Siegel, 1962; Siegel and Schultz, 1963; Schultz and Siegel, 1963b).

The present study attempted to bring these previous developments together in order to provide practical personnel evaluation instruments for the independent dimensions underlying a technical job. Specifically, the study was designed to: (1) investigate the feasibility of developing unidimensional scales along each of the dimensions extracted in a multidimensional scaling analysis of job performance and (2) produce practical scales, meeting the Thurstone and the

Guttman scalability requirements, which could be used for evaluating individual technicians along the four dimensions previously found to underlie the job of the striker and the petty officer, third class, Naval aviation electronics technician.

Starting with 18 tasks found to constitute the job of the striker and the petty officer, third class, Naval aviation electronics technician (AT) (Schultz and Siegel, 1962), two forms were developed and administered to groups of AT supervisors. The first form asked the supervisors to judge each task from the standpoint of its relationship to each of the four underlying job dimensions separately. The second form requested evaluations of individual technicians on the tasks, as the tasks were viewed from the standpoint of each dimension.

For each job dimension, a subset of tasks was found which scaled according to the Thurstone equal appearing intervals method. These groups of tasks also met the requirements of Guttman scales. Support for the validity of multidimensional scaling techniques, as applied in the job task area, was indicated by generally high correlation coefficients obtained between the direct task ratings on each dimension obtained in this study and the task loadings on each dimension obtained in a multidimensional scaling analysis of the job involved.

Conclusions

It seems reasonable to arrive at the following conclusions from the material presented in this report:

1. It is possible to develop unidimensional scales along each of the job dimensions extracted in a multidimensional scaling analysis.

2. Scales meeting the Thurstone and Guttman scalability requirements, which were developed in this study, can be used to evaluate individual technicians along the four dimensions underlying the job of striker and the petty officer, third class, Naval aviation electronics technician.

3. The application of multidimensional scaling methods to a job task constellation produces meaningful, reliable results which can be verified by other experimental procedures.

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APPENDIX A

Appendix A presents the Technical Task Evaluation List employed in the study here reported

TECHNICAL TASK EVALUATION LIST

Name_____ Today's Date_____

Squadron_____ Naval Air Station At_____

Your Rating_____ Your Age_____ Years in Service_____ ___

What is the total number of years you have been an AT?_____ years

How many different squadrons have you been assigned to as an AT? _____

Directions

There are four sections in this form, each containing a number of tasks which are customarily done by AT strikers. You will be asked to evaluate the tasks listed in a section from a certain point of view, but this point of view will differ from one section to another. Therefore, be sure you understand how you are to evaluate the tasks each time. Read the directions for each section very carefully, even though there is some repetition in them.

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APPLIED PSYCHOLOGICAL SERVICES
WAYNE, PENNSYLVANIA

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WITH THE

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Directions for Section 1

In Section 1 there are 18 tasks which call for various amount of knowledge and understanding of the principles of avionic circuitry. First, you should read over the tasks to see what they are. Then, using the scale below as a guide, you are to judge each task ONLY from the standpoint of the knowledge and understanding of the principles of avionic circuitry that it requires. Follow the procedure described in the steps given below. If you wish, before you use the stickers you may write your responses in with a pencil and then go back and attach the stickers.

1	2	3	4	5	6	7	8	9	10	11
REQUIRES LITTLE KNOWLEDGE AND UNDERSTANDING OF PRINCIPLES OF AVIONIC CIRCUITRY				REQUIRES MODERATE KNOWLEDGE AND UNDERSTANDING OF PRINCIPLES OF AVIONIC CIRCUITRY				REQUIRES GREAT KNOWLEDGE AND UNDERSTANDING OF PRINCIPLES OF AVIONIC CIRCUITRY		

1. First place the sticker with the 11 on it next to the task that requires the greatest knowledge and understanding of the principles of avionic circuitry.

2. Then pick the task that requires the next greatest knowledge and understanding of avionic circuitry and put the sticker with the 10 on it next to that task.

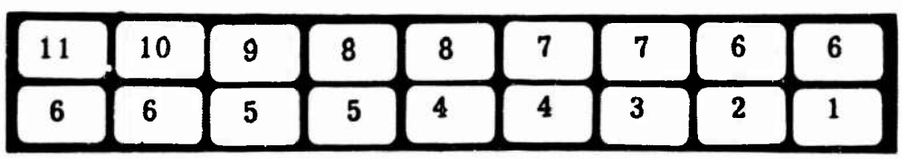
3. Now find the task that falls in category "nine" and place the sticker with the 9 on it next to that task.

4. Next find the task that requires the least knowledge and understanding of the principles of avionic circuitry. Put the sticker with the 1 on it next to this task.

5. Which task requires the next smallest knowledge and understanding of avionic circuitry? Put the sticker with the 2 on it next to this task.

6. Put the sticker with the 3 on it next to the task that falls in category "three."

7. Now place the remaining tasks in their proper categories by applying the remaining stickers (4, 5, 6, 7, 8).



SECTION 1

To what extent is knowledge and understanding of the principles of avionic circuitry required in

	Scale Value
1. Replacing repaired avionic parts/equipment in planes	
2. Following block diagrams for avionic equipments	
3. Using safety precautions on equipments	
4. Performing intermediate inspections of avionic equipments	
5. Using inspection and operation manuals	
6. Removing malfunctioning avionic parts/equipment from planes	
7. Operating standard test equipment for determining malfunctions in avionic equipments	
8. Performing preflight inspections of avionic equipments	
9. Performing routine line operations	
10. Performing preventive maintenance on avionic equipments	
11. Performing postflight inspections of avionic equipments	
12. Performing variety of "housekeeping" duties such as cleaning shop, repairing tools, etc.	
13. Operating avionic equipments	
14. Using schematics for standard circuits in avionic equipments	
15. Making out reports (failure, etc.)	
16. Performing minor inspections of avionic equipments	
17. Standing watch	
18. Using proper safety precautions for self	

Directions for Section 2

In Section 2 there are 12 tasks which require various levels of ability in equipment turn-on, warm-up, run, and shut-down procedures. Although the same tasks were all included in the list you judged in Section 1, this time you are to evaluate them from the standpoint of equipment turn-on, warm-up, run, and shut-down procedures.

First, you should read over these tasks to see what they are. Then, using the scale shown below as a guide, you are to judge each of these tasks ONLY from the standpoint of the level of ability in equipment turn-on, warm-up, run, and shut-down procedures which it requires. Follow the procedure described in the steps given below. Again, if you find it helpful, you may write in your responses with pencil and then go back and attach the stickers over your penciled numbers.

1	2	3	4	5	6	7	8	9	10	11
REQUIRES LOWEST ABILITY LEVEL IN EQUIPMENT TURN-ON, WARM-UP, RUN, AND SHUT-DOWN PROCEDURES				REQUIRES MODERATE ABILITY LEVEL IN EQUIPMENT TURN-ON, WARM-UP, RUN AND SHUT-DOWN PROCEDURES				REQUIRES HIGHEST ABILITY LEVEL IN EQUIPMENT TURN-ON, WARM-UP, RUN, AND SHUT-DOWN PROCEDURES		

1. First, place the sticker with the 11 on it next to the task that requires the highest level of ability in equipment turn-on, warm-up, run, and shut-down procedures.

2. Next, find the task that involves the next highest level of ability in equipment turn-on, warm-up, run, and shut-down procedures and put the sticker with the 10 on it next to that task.

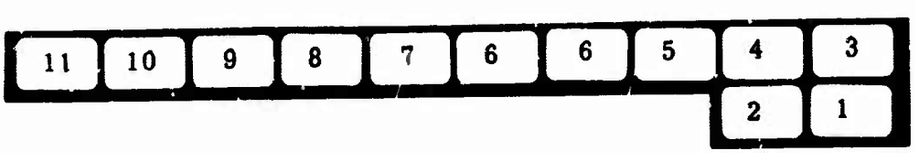
3. Now find the task that falls in category "nine" and place the sticker with the 9 on it next to that task.

4. Then look for the task that requires the lowest level of ability in equipment turn-on, warm-up, run, and shut-down procedures. Put the sticker with the 1 on it next to this task.

5. Which task requires the next lowest level of ability in equipment turn-on, warm-up, run, and shut-down procedures? Put the sticker with the 2 on it next to this task.

6. Put the sticker with the 3 on it next to the task that falls in category "three".

7. Now place the remaining tasks in their proper categories by applying the remaining stickers (4, 5, 6, 7, 8).



SECTION 2

What level of ability in equipment turn-on, warm-up, run, and shut-down procedures is required in

	Scale Value
1. Performing minor inspections of avionic equipments	
2. Operating avionic equipments	
3. Performing routine line operations	
4. Standing watch	
5. Performing preventive maintenance on avionic equipments	
6. Performing intermediate inspections of avionic equipments	
7. Performing preflight inspections of avionic equipments	
8. Removing malfunctioning avionic parts/equipment from planes	
9. Operating standard test equipment for determining malfunctions in avionic equipments	
10. Performing postflight inspections of avionic equipments	
11. Making out reports (failure, etc.)	
12. Replacing repaired avionic parts/equipment in planes	

Directions for Section 3

This time you are to evaluate many of the same tasks from another point of view. You are to think of the 9 tasks in Section 3 in terms of the removal of, making required corrections in, and replacement of avionic equipment involved. The question you should ask yourself about each task is, "What level of ability in the removal of, making the required corrections in, and the replacement of avionic equipment is required in this task?"

Again you should first read over these tasks to see what they are. Then, using the scale shown below as a guide, you are to judge each of these tasks ONLY from the standpoint of the removal of, making required corrections in and the replacement of avionic equipment.

Follow the same procedure you used in the previous sections. That is, first select the three tasks which require the highest level of ability in the removal of, making the required corrections in, and the replacement of avionic equipment and place stickers 9, 8, and 7 next to them. Next, find the three tasks which require the lowest level and place stickers 1, 2, and 3 next to them. Then, use the remaining stickers to indicate your judgement of the remaining tasks.

1	2	3	4	5	6	7	8	9	10	11

REQUIRES LOWEST LEVEL OF ABILITY IN THE REMOVAL OF, MAKING REQUIRED CORRECTIONS IN, AND THE REPLACEMENT OF AVIONIC EQUIPMENT

REQUIRES MODERATE LEVEL OF ABILITY IN THE REMOVAL OF, MAKING REQUIRED CORRECTIONS IN, AND THE REPLACEMENT OF AVIONIC EQUIPMENT

REQUIRES HIGHEST LEVEL OF ABILITY IN THE REMOVAL OF, MAKING REQUIRED CORRECTIONS IN, AND THE REPLACEMENT OF AVIONIC EQUIPMENT

SECTION 3

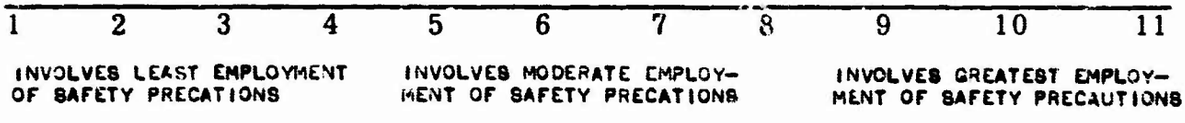
What level of ability in the removal of, making the required corrections in, and the replacement of avionic equipment is required in

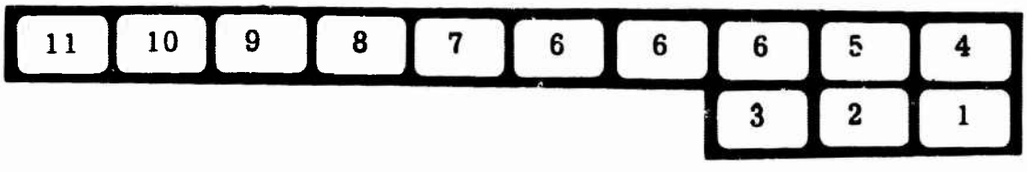
	Scale Value
1. Performing postflight inspections of avionic equipments	
2. Performing preflight inspections of avionic equipments	
3. Operating avionic equipments	
4. Performing preventive maintenance on avionic equipments	
5. Operating standard test equipment for determining malfunctions in avionic equipments	
6. Performing routine line operations	
7. Performing intermediate inspections of avionic equipments	
8. Performing minor inspections of avionic equipments	
9. Standing watch	

Directions for Section 4

The last group of 13 tasks, shown in Section 4, is to be evaluated from the point of view of the extent to which the employment of safety precautions is involved. Read over the tasks in the list and then, using the scale shown below as a guide, judge each one ONLY from the standpoint of the extent to which safety precautions are employed.

Use the same procedure as you did in the previous sections. Start by finding the three tasks which involve the greatest employment of safety precations and place stickers 11, 10, and 9 next to them. Next, place stickers 1, 2, and 3 next to the three tasks which involve the least employment of safety precautions. Last, use the remaining stickers to indicate your judgments of the remaining tasks.





SECTION 4

To what extent are safety precautions employed in

	Scale Value
1. Performing preflight inspections of avionic equipments	
2. Making out reports (failure, etc.)	
3. Performing preventive maintenance on avionic equipments	
4. Performing postflight inspections of avionic equipments	
5. Operating avionic equipments	
6. Removing malfunctioning avionic parts/equipment from planes	
7. Performing minor inspections of avionic equipments	
8. Standing watch	
9. Performing routine line operations	
10. Performing intermediate inspections of avionic equipments	
11. Operating standard test equipment for determining malfunctions in avionic equipments	
12. Following block diagrams for avionic equipments	
13. Replacing repaired avionic parts/equipment in planes	

APPENDIX B

Appendix B presents the Proficiency Check List employed in the study here reported

PROFICIENCY CHECK LIST

Your Name _____ Today's Date _____

Directions

Think of an AT striker whom you have supervised and whose capabilities you know well. You are to evaluate him in four different ways. There are four sections in this form, each containing a number of tasks which are customarily done by AT strikers. You will be asked to evaluate the man you are considering with respect to the various tasks from a certain point of view, but this point of view will differ from one section to another. Therefore, be sure you understand how you are to do the evaluations each time. Read the directions for each section very carefully, even though there is some repetition in them.

Write down a response for every task. If the man you are evaluating has not done a task or if you have not seen him do it, try to make your best estimate of the evaluation.

Name of Man You are Rating _____

His Squadron _____ Naval Air Station At _____

His Rating _____

How long have you known him? _____ months

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Directions for Section 1

In Section 1 there are 18 tasks which call for various amounts of knowledge and understanding of the principles of avionic circuitry. You should think of the man you are evaluating. Does he have the knowledge and understanding of the principles of avionic circuitry required by the first task? If he does, make a check in the box under "Yes"; if he does not, make a check in the box under "No." Then look at the second task and indicate your evaluation of the man by a check mark in the appropriate box. Continue on down the page making a check mark in one box next to each task. Remember, you are to evaluate the man ONLY with respect to whether or not he has the knowledge and understanding of the principles of avionic circuitry required by each task. Even if he has not done the task or if you have not seen him do it, make your best estimate of his capability with regard to it. Be sure to make a check mark next to each task in the list.

SECTION 1

Does he have the knowledge and understanding of the principles of avionic circuitry required by

	Yes	No
1. Performing variety of "housekeeping" duties such as cleaning shop, repairing tools, etc.		
2. Following block diagrams for avionic equipments		
3. Replacing repaired avionic parts/equipment in planes		
4. Making out reports (failure, etc.)		
5. Performing preflight inspections of avionic equipments		
6. Operating standard test equipment for determining malfunctions in avionic equipments		
7. Standing watch		
8. Using proper safety precautions for self		
9. Using safety precautions on equipments		
10. Performing intermediate inspections of avionic equipments		
11. Operating avionic equipments		
12. Using inspection and operation manuals		
13. Performing routine line operations		
14. Performing minor inspections of avionic equipments		
15. Removing malfunctioning avionic parts/equipment from planes		
16. Using schematics for standard circuits in avionic equipments		
17. Performing postflight inspections of avionic equipments		
18. Performing preventive maintenance on avionic equipments		

Directions for Section 2

In Section 2 there are 12 tasks which involve equipment turn-on, warm-up, run, and shut-down procedures to a varying degree. Although the same tasks were all included in the list in Section 1, this time you are to view them from the standpoint of equipment turn-on, warm-up, run, and shut-down procedures.

Think of the man you are evaluating. Is he capable of performing proficiently the equipment turn-on, warm-up, run, and shut-down procedures involved in the first task "on his own" without direct supervision? If he is, make a check mark in the column under "Yes"; if he is not, make a check mark in the column under "No." Then, look at the second task and indicate your evaluation of the man by a check mark in the appropriate column. Continue on down the page. For each task, evaluate the man ONLY with respect to whether or not he is capable of performing proficiently the equipment turn-on, warm-up, run, and shut-down procedures involved in that task "on his own" without direct supervision. Make a check mark next to each task, estimating his capability if he has not done the task or if you have not seen him do it.

SECTION 2

Is he capable of performing proficiently the equipment turn-on, warm-up, run, and shut-down procedures involved in

	Yes	No
1. Operating avionic equipments		
2. Operating standard test equipment for determining malfunctions in avionic equipments		
3. Making out reports (failure, etc.)		
4. Performing postflight inspections of avionic equipments		
5. Standing watch		
6. Performing preflight inspections of avionic equipments		
7. Replacing repaired avionic parts/equipment in planes		
8. Performing routine line operations		
9. Performing preventive maintenance on avionic equipments		
10. Removing malfunctions avionic parts/equipment from planes		
11. Performing intermediate inspections of avionic equipments		
12. Performing minor inspections of avionic equipments		

Directions for Section 3

Section 3 contains 9 tasks which vary in terms of the extent to which they involve removal of, making required corrections in, and replacement of avionic equipment.

Think of the man you are evaluating. Is he capable of performing proficiently the removal of, making required corrections in, and the replacement of avionic equipment involved in the first task "on his own" without direct supervision? Make a check mark in either the "Yes" or "No" box next to the task, according to your best judgment. Continue on down the page. Remember to evaluate the man ONLY with respect to whether or not he is capable of performing the removal of, making required corrections in, and the replacement of avionic equipment involved in that task "on his own" without direct supervision. Be sure to make a check mark next to each of the 9 tasks.

SECTION 3

Is he capable of performing proficiently the removal of, making required corrections in, and the replacement of avionic equipment involved in

	Yes	No
1. Performing intermediate inspections of avionic equipments		
2. Performing routine line operations		
3. Performing preflight inspections of avionic equipments		
4. Operating avionic equipments		
5. Performing preventive maintenance on avionic equipments		
6. Performing minor inspections of avionic equipments		
7. Performing postflight inspections of avionic equipments		
8. Standing watch		
9. Operating standard test equipment for determining malfunctions in avionic equipments		

Directions for Section 4

This time the 13 tasks listed in Section 4 are to be viewed from the standpoint of the safety precautions that they involve.

Follow the same procedures you did in the previous sections. Ask yourself this question about the man you are evaluating: Is he capable of performing the safety precautions involved in the first task "on his own" without direct supervision? Place a check mark in the appropriate box. Ask the same question with regard to the other tasks in the list and make an appropriate check mark next to each task according to your answer to the question. Remember, you should make your evaluation ONLY with respect to whether or not he is capable of performing the safety precautions involved in each task.

SECTION 4

Is he capable of performing the safety precautions involved in

	Yes	No
1. Following block diagrams for avionic equipments		
2. Operating avionic equipments		
3. Performing minor inspections of avionic equipments		
4. Performing preventive maintenance on avionic equipments		
5. Replacing repaired avionic parts/equipment in planes		
6. Performing routine line operations		
7. Operating standard test equipment for determining malfunctions in avionic equipments		
8. Performing postflight inspections of avionic equipments		
9. Performing preflight inspections of avionic equipments		
10. Performing intermediate inspections of avionic equipments		
11. Removing malfunctioning avionic parts/equipment from planes		
12. Making out reports (failure, etc.)		
13. Standing watch		